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Verification of Equation of Energy-Mass Equivalence

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Abstract

The equation of conversion of mass to energy and from energy to mass is given by $E = mc^2$. In this paper, this equation is verified using one simple equation. This paper illustrates two concepts, firstly, the energy-mass equivalence and secondly, a simple method for verification of such equations.

Keywords: Energy; Mass; Verification; Change

1. INTRODUCTION

Conversion of energy to mass and from mass to energy is an important concept irrespective of the discipline. It has significance from mechanics to electronics. In this paper, this concept is verified using a simple law of physics [1]. The paper may be first of its kind to demonstrate energy-mass equivalence by verifying it against a simple well known equation in physics.

2. METHODOLOGY

The total mechanical energy at any given point of time is obtained by adding the kinetic and potential energy at this point of time [1]. It is shown in equation (1).

$$Total\ mechnical\ energy = Kinetic\ Energy + Potential\ Energy \qquad (1)$$

$$or\ E = K.E + P.E$$

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The kinetic energy at any point of time is given by equation (2) [1]

$$K.E = \frac{1}{2}mv^2 \tag{2}$$

Where m is the mass and v is the velocity [1]. At equilibrium position, the potential energy is completely connverted into kinetic energy. An example of equilibrium position is shown in the figure (1) below. At the point where the mass is farthest from the equilibrium, the acceleration becomes zero since there is no change in the velocity and the ball stops to change the direction of displacement. Since there is a change in direction of displacement, the ball must have some velocity at the point farthest from equiilibrium. The change in velocity is zero since there is no change in magnitude of velocity and direction of velocity remains same as shown in figure (1) below, that is towards equilibrium position for some instant of time. Assuming that the speed of ball is v at the point farthest from equilibrium, than its kinetic energy is given by equation (3)

$$K.E = \frac{1}{2}mv^2 \tag{3}$$

The net potential energy is converted into kinetic energy at the equilibrium position (lowest point in figure (1)). If kinetic energy is given by (2), than only change is conversion of potential energy to kinetic energy. Assuming the potential energy is equal to kinetic energy at the point farthest from the equilibrium, than potential energy is same as kinetic energy as in equation (3). Therefore, total energy from equaiton (1) becomes:

$$E = K.E + P.E$$

$$E = \frac{1}{2}mv^2 + \frac{1}{2}mv^2$$

$$E = mv^2 \tag{4}$$

Assuming the speed to be c, the equation (4) becomes

$$E = mc^2 \tag{5}$$

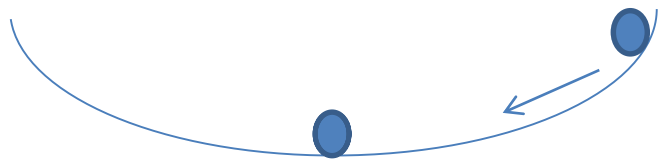

Figure 1: Ball going to equilibrium position from the point it was farthest from equilibrium

This equation is verified against equation (1) since all the assumption made hold true for equation (1) above and the proof began from equation (1).

3. CONCLUSION

After proving the mass-energy equivalence equation, similar proofs could be done for other complex equations as well. This method includes beginning from a equation and then making assumptions that are true for this equation and finally obtaining the desired equation.

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